

NASA steps up efforts
to redesign space shuttle
Page 7

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Titanium Dioxide

Producers expect best year ever

Page 15

News of the Week

■ **House/Senate conferees resolve nontax issues in compromise Superfund bill.** Page 4

■ **Jury finds W. R. Grace & Co. responsible for contributing to contamination of municipal wells in Woburn, Mass.** Page 5

■ **No harmful effects resulted when boxcars containing insecticide and chemicals were blown off a trestle during a windstorm near Des Moines, Iowa.** Page 5

■ **OSHA proposes standards for lab workers' exposure to toxic substances.** Page 6

■ **Nobelist Fritz A. Lipmann, discoverer of coenzyme A, is dead at age 87.** Page 6

Cover: Du Pont's DeLisle, Miss., plant is largest single-line titanium dioxide facility in the world

Letters	2
Concentrates	
Business	13
Government	17
Science/Technology	20
The Department	
Newsclips	40

Business

Titanium dioxide producers expect best year ever as prices hold firm and production and consumption rise. Page 15

Government

Study of safety at chemical plants by the Occupational Safety & Health Administration finds deficiencies in present inspection system. Page 18

Technology

Liquid-phase process for methanol synthesis is being developed by researchers at Brookhaven National Laboratory. Page 21

Methods to use microwave ovens to dissolve samples for elemental trace analysis are being developed. Page 22

Books

"The Ageless Gergel" relates episodes from the author's life as an entrepreneur running a small chemical business. Page 23

ACS News

ACS Council will decide on planning document and four petitions when it convenes at society's national meeting in Anaheim. Page 25



News Focus

NASA works to redesign space shuttle following recommendations of Presidential commission, aiming for an early 1988 launch. Page 7

Titanium Dioxide Producers Expect Best Year Ever

Prices for largest-volume white pigment hold firm as production and consumption rise and capacity expansion programs continue

Bruce F. Greek, C&EN Houston

Titanium dioxide consumption in the U.S. this year will rise to a new high, giving producers their best year ever. The growth in demand will push up production as well as increase the net of imports over exports. Demand, production, and imports all have increased substantially, but this growth will slow later this year. Supplies are tight, with selling prices very close to list prices, which recently were raised.

Production, tempered somewhat by maintenance requirements, is expected to remain high during the rest of the year. Imports may decline as consumption slows because of its seasonal pattern. Inventories of titanium dioxide have been low, but they likely will be rebuilt slightly this fall.

According to preliminary estimates, U.S. production of titanium dioxide this year is forecast to exceed 830,000 tons, up 2% from 1985. Some industry sources question the validity of the 1985 government production figure, however, saying the estimate is low because it is more than 20,000 tons less than the 1984 production estimate for a year when demand was as strong or stronger than in 1984. Producers say that last year they were responding to increased demands from most titanium dioxide uses and were drawing down inventories to meet those demands. The net of imports over exports in 1985 was up 7000 tons from

the year before to 94,000 tons, which was only a minor addition to supplies for the year. Thus, producers explain, for the government to report decreased production calls the figures into question.

If production estimates for 1985 are revised, the total may be very close to the 1984 volume or higher, according to sources. Should the 1985 production estimate end up being 835,000 to 840,000 tons, then production plus the net of imports over exports and inventory draw-down would about equal consumption, which is estimated to be in the range of 930,000 to 940,000 tons.

Producers this year could add another 10,000 to 15,000 tons to supply. If the net of imports over exports increases about 5000 to 10,000 tons, consumption theoretically might rise 15,000 to 25,000 tons, to more than 950,000 tons. Such an increase in consumption likely will not occur, however, since use is forecast to grow only 1 to 1.5% in 1986. Consumption more likely will in-

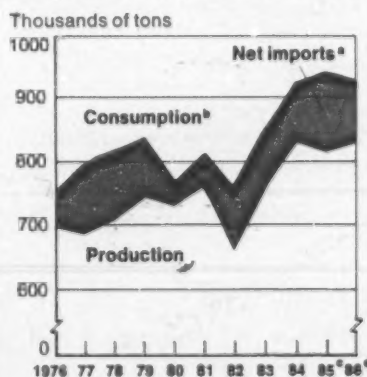
crease 8000 to 10,000 tons in 1986, allowing the additional production and imports to augment the low inventories.

Producers are again operating their plants at very high levels. For 1986 production to total the lowest estimate of 830,000 tons, the capacity of 890,000 tons that existed at the beginning of the year would have to be operated at 93% of the nameplate total. Expansions and debottlenecking programs, however, are adding to capacity. Early this year, Kerr-McGee completed an 8000 ton-per-year addition to its capacity, which could increase production about 6000 tons during the year. Debottlenecking at other facilities could add at least as much—possibly 10,000 tons—to the nameplate capacity total. Much of it will come from Du Pont's expansion program, which is designed to add a total of 50,000 tons of capacity to its four U.S. titanium dioxide plants by the end of 1988. Should the additions bring the average nameplate capacity total for the year up to 900,000 tons and production reach 850,000 tons, the average plant operating rate would be even higher—more than 94%.

If plants are operated at that kind of rate for long periods, producers likely will be able to keep their selling prices up. Last fall, prices increased 4 cents a lb, to 74 cents, for the anatase form of titanium dioxide, and 78 cents a lb for the rutile form.

Other than cost savings, which result from technological improvements at plants, the major area of cost reduction for producers is transportation savings that result from lower oil prices. Those savings, however, are offset by the additional costs of improved water pollution control and of waste disposal from

TiO₂ consumption varied erratically in past decade



^a Imports minus exports. ^b Includes shifts in inventories. ^c Preliminary. ^d Estimates. Sources: Department of Commerce, Bureau of Mines, C&EN estimates

manufacturing. Most of the wastes are iron chlorides and iron sulfate, which is a great problem for plants using the sulfate process.

Even though prices for titanium dioxide are now firm and higher, returns aren't enough to justify building a plant. A new plant in the U.S. could cost \$2000 per ton of annual capacity, with present world-scale plants having a capacity of at least 30,000 tons per year. If a plant with such a capacity operated at 90% of nameplate, a payout in four years would require a 28 cent-per-lb capital-cost burden. As a result, it is not economically feasible to build new plants, so extensive debottlenecking programs are expected to continue well into the 1990s.

Even so, supplies of titanium dioxide will remain tight. Exports of the pigment could decline about three years from now when new capacity in various parts of the world comes on stream to fill demand in areas such as the Far East. However, U.S. imports also could decline as demand picks up in Europe (which is the source of much of the imported material), and as capacity there declines because of pressure to reduce pollution from plant effluents. The yet unbuilt foreign plants could be a future source of imports to the U.S. in the 1990s.

For the past two years, producers have managed to stay ahead of demand increases through their debot-

tlenecking programs and increased operating rates. Demand has risen steadily, but at a relatively low rate for the chemical industry—1 to 2% annually. The major uses of titanium dioxide—coatings, paper, and plastics—have accounted for nearly all of the growth in consumption. That pattern likely will continue.

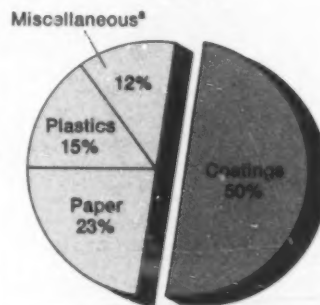
Half of U.S. consumption of titanium dioxide is used for coatings. Roughly two thirds of that is employed in exterior and interior paints. On average, more than 1 lb of titanium dioxide is used in every gallon of finished paint.

The architectural paint demand (to distinguish from paint for autos and other products) for titanium dioxide has been especially strong in 1986, because lower mortgage rates have encouraged new house construction, and that has stepped up sales of older houses. That usually involves painting all or a major part of the house before or soon after the sale.

About 20 to 25% of total coatings are used on products such as cars, machinery, appliances, containers, and many other consumer items. Demand for most of those products has been increasing modestly this year. The remainder of the nonarchitectural coatings go for repainting or refinishing in such varied uses as road stripping and auto repainting.

For these various uses for coatings, the net gain in consumption

Coatings dominate uses of titanium dioxide



Total 1986 consumption
= 920,000 tons

* Includes ceramics, elastomers, fabrics and textiles, floor coverings, inks, and others.
Source: C&EN estimates

of titanium dioxide this year will be more than 1%, or about 5000 tons. That will be half of the expected growth in consumption for the year.

Paper takes nearly another quarter of titanium dioxide consumption. The use in paper also will increase only modestly, because of variations in demand for paper and paperboard. Demand for coated papers used in higher-quality printing will be down, whereas demand for uncoated paper and paperboard containing titanium dioxide added during manufacture will be up. The latter increase results from greater demand for data processing print-out paper and for packaging.

Among the large uses, plastics have been the fastest-growing market, rising about 3% this year. Some part of the manufacture of all major thermoplastics requires titanium dioxide. Roughly a third of the titanium dioxide consumed in plastics goes into polyvinyl chloride pipe, fittings, siding, and various profiles. Another third is used for pigment polyolefins, and the rest goes into other plastics, including small-volume thermoplastics and thermosets.

The remainder of titanium dioxide is consumed in myriad small uses. The largest are ceramics, elastomers, and ink. None of the miscellaneous uses are growing very much. Many are declining in their share of consumption because their growth is even lower than that of coatings or paper. □

Titanium dioxide pigment at a glance

Description: Produced in larger quantities than any other white pigment, TiO_2 has best hiding power of any white pigments. Commercial production is concentrated in two crystalline forms, anatase and rutile grades. Rutile form has a higher density, refractive index, hiding power, and slightly higher cost. Used to provide opacity in coatings, paper, plastics, and many smaller uses

Production: 815,000 tons (both forms) in 1985; 830,000 tons estimated for 1986

Imports: 196,000 tons in 1985; 200,000 tons estimated for 1986

Exports: 102,000 tons in 1985; 100,000 tons estimated for 1986

Manufacturing processes: Involve ore beneficiation of ilmenite, preparation of TiO_2 slag by electrolytic smelting, beneficiation of natural rutile, and preparation of synthetic rutile by reduction and leaching. Ores and slag then reacted with sulfuric acid and iron (sulfate process) or chlorine and oxygen (chloride process) to produce pigment grades of TiO_2

Capacity: About 900,000 tons at beginning of 1986

Producers: Du Pont, Kemira (Finnish-owned), Kerr-McGee, SCM

Prices: 74 cents per lb for anatase; 78 cents per lb for rutile (at midyear)

OSHA Issues Interim Report on Special Emphasis Program

In-depth study of safety at chemical plants identifies deficiencies in routine inspections that will effect changes in agency's approach

David J. Hanson, C&EN Washington

Frightened by the possibility of an industrial chemical accident on the magnitude of the one in Bhopal, India, the Occupational Safety & Health Administration last year began what it calls a Chemical Industry Special Emphasis Program to try to minimize the chances of such an occurrence. The initial phase of that program, in effect since January, is scheduled to end in November. OSHA has just issued an interim report on its progress.

OSHA says its findings are still highly preliminary, and it doesn't make any comment on the actual inspections themselves or how individual chemical plants fared in the process. But the special emphasis of this program is identifying enough deficiencies in the present system that it will change permanently the way OSHA inspects chemical plants.

After the Bhopal accident in December 1984, OSHA was under extreme pressure from Congress to assure the public that such a catastrophe could not happen in the U.S. OSHA inspected all the plants where methyl isocyanate—the chemical involved in the Bhopal deaths—was being manufactured. Although some violations of safety and health standards were found, there did not appear to be any imminent danger. Then, on Aug. 11, 1985, Union Carbide's plant in Institute, W.Va., experienced a leak of dichlorometh-

ane and aldicarb oxime that sent more than 100 nearby residents to hospitals with minor complaints. After the initial investigation of that incident, OSHA went into the Institute plant and did a wall-to-wall inspection of all 18 units, concluding there were some gross oversights in the way the company was handling hazardous material. Eventually the agency fined Carbide \$1.4 million (C&EN, April 7, page 4). Carbide has appealed the fine.

Soon thereafter, acting assistant secretary of Labor Patrick R. Tyson announced the special emphasis program. OSHA had become aware, after the inspections for MIC, that its enforcement program needed to cover more than the physical conditions of the plant equipment—the company's management policies, its protective systems, and safe work practices also needed to be scrutinized. "Inspections conducted under the new special emphasis program will pay particular attention to safety processes in order to assess the adequacy of those processes in preventing and containing leaks and spills," Tyson told the House Subcommittee on Health & Safety last October. "The focus will be on preventing future hazards as well as discovery of existing ones."

In the current pilot-scale project OSHA is trying to inspect units producing hazardous materials at about 80 chemical plants scattered throughout four OSHA regions. At this time, OSHA inspectors have been able to make only 32 inspections, according to John B. Miles, director of OSHA field operations. It is turning out that these inspections are taking a great deal of time. Each inspection requires a two-member team of OSHA officers—a safety inspector and an industrial hygienist—and it is taking up to eight weeks

or longer to complete a job. This is much longer than a routine inspection, which is done by one officer. OSHA says that the two-member teams can do no more than eight to 10 inspections each year, meaning they are in effect skipping 120 to 150 inspections elsewhere. Miles says that this is expected to eat somewhat into the regular OSHA inspection schedule for chemical plants, but that the year's total should still be near the 1400 inspections done in the past.

The agency is having a problem deciding which plants to inspect. OSHA wanted to get to those plants producing the chemicals most hazardous to the workers or surrounding communities. Having no such list of dangerous chemicals of its own, OSHA turned to a list prepared by the European Economic Community of high-risk chemicals, also known as the International Labor Organization list. The agency chose the 120 highest ranked chemicals as its targets. Then, with help from the Environmental Protection Agency, OSHA tried to match up those chemicals with manufacturers as listed in the Toxic Substances Control Act inventory list, compiled in 1978. One difficulty encountered right away was that the TSCA list does not include pesticides, whereas the ILO list does.

Unfortunately, the plants EPA thought were manufacturing those chemicals sometimes no longer were doing so. According to the interim report, this method of targeting plants may be workable, but not very efficient. Results so far are uneven. Sometimes inspectors went to plants only to find out the targeted chemical was no longer produced there. That happened to teams sent out by OSHA's Chicago regional office eight times, for instance. The

Dallas office, however, had no misdirected inspectors. In all, the report concludes that the system was sending teams to the wrong sites about half the time. The effectiveness of the list has been improved by doing more work with local offices, comparing their records with the target chemicals list as well as state-maintained lists of chemical manufacturers.

Still, the system has allowed OSHA at least to begin detailed inspection of 32 plants, of which only 14 were complete enough at the time of the report to be included. Each team is inspecting one unit at each plant, the one used to produce the target hazardous chemical. Of the plants inspected so far, phosgene is the most common target, comprising about half the inspections listed in the interim report. By inspecting in great detail the management's "paper program" for handling those chemicals, the OSHA inspectors hope to determine if it is actually being used in practice.

The inspections are geared to pay special attention to any hazards that are not covered by specific OSHA standards. OSHA says this means inspectors will have to use industry consensus standards and recognized industry practices to make safety evaluations. In such situations, the so-called general-duty clause of the

Occupational Safety & Health Act is applied (under section 5[a][1]) when making citations. The inspectors are also encouraged to note problems where there are no consensus standards or codes and make recommendations for changes to employers. The employers will have to respond in writing within 30 days. According to OSHA, the general-duty clause citations in the first set of inspections covered hazards involving materials handling, lockout of safety relief devices, protection of breathing air supply, and process design problems. Recommendations to employers have involved ventilation problems, training, emergency procedures, respirator programs, pressure vessel inspection schedules, scrubber capacity, instrumentation, and a variety of process and electrical hazards.

OSHA estimates that the inspectors spent 80% of their time reviewing on-site health and safety program materials and reviewing the diagrams and dynamics of production processes. Some companies keep better records than others, Miles says, and even though these plants may be very safe, it's taking longer just to go through that process.

As a demonstration project, the scale of the program is not so large as it could be, and some compromise had to be made between the

availability of resources and size of the situation. Complete wall-to-wall inspections, which would take several teams of inspectors months to complete, were out of the question, even an inspection the size of the one done at Carbide in Institute. Inspection of a single unit can supply information for future inspections, however. If there are many problems uncovered with a hazardous chemical unit, OSHA may conclude the rest of the plant may need a closer look as well and go further. Miles says that so far the chemical industry has been very cooperative, and that a lot of positive things are being found.

The very preliminary nature of the data so far doesn't permit OSHA to make any evaluation of the special emphasis program yet, according to Miles. "It's still too early to draw conclusions about the inspections," he says. "There are no trends yet in the citations. We aren't finding a lot of things," he adds. And the goal of 80 unit inspections may have been optimistic in view of the time it is taking for each evaluation, but OSHA is not moving from this ideal yet. The detailed inspections are viewed as valuable. "We need a presence in the chemical industry," Miles says, "if just to know what is going on." Whether the pilot program will be continued or expanded next year will have to be decided later, he continues. "Right now, I don't see expanding the program; it's just too resource-intensive."

However, the special emphasis program already has prompted OSHA to develop a closer working relationship with other agencies involved in health and safety. Much information is being shared with EPA, and the report says the two agencies plan to conduct preliminary joint inspections this year to see if some kind of practical joint inspection protocol can be developed. Greater cooperation with the Nuclear Regulatory Commission is also becoming a concern. The report mentions the release of uranium hexafluoride from a storage tank at Sequoyah Falls Corp. near Gore, Okla.; in January as an example of the kinds of hazards present in the nuclear industry. □

Most plants inspected in special program make phosgene

Plant	Chemical traced	Daily capacity	Inspection length, hours
Chevron, Cleves, Ohio	Hydrogen sulfide	800 cu ft	432
Dow Chemical, La Porte, Tex.	Phosgene	207 tons	558
Du Pont, Linden, N.J.	Sulfur trioxide ^a	na	398
Du Pont, Niagara Falls, N.Y.	Chlorine	240 tons	172
Liquid Air, Euclid, Ohio	Acetylene	7200 cu ft	97
Mobay, Baytown, Tex.	Phosgene	604 tons	399
Olin, Lake Charles, La.	Phosgene	140 tons	526
PPG Industries, La Porte, Tex.	Phosgene	35 tons	204
Rubicon, Geismar, La.	Phosgene	280 tons	246
Scientific Gas, South Plainfield, N.J.	Hydrogen selenide	na	na
Stauffer Chemical, Edison, N.J.	Bis(chloromethyl)-ether	na	558
Twin Lakes, Lockport, N.Y.	Phosgene ^b	0	136
Two-Six, Saxonburg, Pa.	Hydrogen selenide	18 lb (batch)	206
Union Carbide, West Mifflin, Pa.	Acetylene	1000 lb	150
Van de Mark, Lockport, N.Y.	Phosgene	3 tons	274

^a Originally targeted for formaldehyde. ^b Not yet producing phosgene, recommendations based on assessment of plans. na = not available. Source: OSHA